

4. *Palæoniscus* — ? n. sp.

A single example of what appears to be another species of *Palæoniscus* has occurred along with those described. It is about 3 inches long, a little more than half an inch in depth, and its head is $\frac{7}{10}$ inch in length. It differs from the species noticed in having a more pointed head and a produced snout, also in the greater length of its dorsal, anal, and caudal fins. As it seems, however, to possess some points of resemblance to *Palæoniscus angustus*, Ag., of the Zechstein, I refrain from describing it as new until I have compared it carefully with that species.

Acrolepis Sedgwickii, Ag.

Associated with the *Palæonisci* there has occurred a single fragment of *Acrolepis*, apparently belonging to the species *A. Sedgwickii* of the Marl-slate. This specimen is 7 inches long, and is minus head and part of tail, so that it has probably belonged to an individual that was little under 12 inches in length. Other fragments of this species have also been met with in the limestone above the bed containing the *Palæonisci*, but in a more imperfect state of preservation than the first.

Besides these remains of fish, there have also been found in the two-feet bed first mentioned, and in the adjoining overlying and underlying strata, a few remains of plants. They are, unfortunately, very imperfectly preserved, and hence very difficult to determine. They are evidently, however, the remains of terrestrial vegetation; at least, they possess character enough to show that they do not belong to the Algæ.

XXX.—*Observations on the Geographical Distribution of Fungi.*

By M. E. P. FRIES*.

THE Algæ and the Fungi properly so called are distinguished from other cellular plants by their larger size, their brighter colours, and by the greater variety of forms met with among them. These two orders of cellular plants have attracted the attention of observers from an early period, and were indeed the only Cryptogamia which at a remote period were applied to use; for it is only within a comparatively recent date that the Lichens have acquired a corresponding interest: on the other

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hand, the Mosses, Hepaticæ, and lower forms of Algæ have not hitherto been available for any useful purpose, and the Mucedines are chiefly known by the injurious effects they produce to other plants. These considerations afford an explanation of the circumstance that the Greeks and Romans distinguished so long ago a considerable number of species of Algæ and Fungi, principally of such as were either useful or noxious, whilst they completely neglected the other tribes of Cryptogamic plants, as is illustrated by the fact that they comprehended under the collective name of Muscus the whole class of Mosses.

Upon the revival of botanical science in the sixteenth century, the Fungi attracted the attention of naturalists beyond all other cellular plants. In the course of this century, in 1583, Cæsalpinus published his famous work '*De Plantis*,' in which the Fungi were not forgotten. But the first work of a special character devoted to this class of plants was that of Charles de l'Ecluse, published in 1601, entitled '*Fungorum in Pannoniis observatorum brevis historia*,' and at a later date the '*Theatrum Fungorum*' of Sterbeeck. These two works treated especially of the higher Fungi. Subsequently a multitude of treatises on the Fungi in general were produced, among which several survive to our time and still possess great value—such, for instance, as those of Vaillant, Micheli, Battara, and Schæffer. It was not until the eighteenth century that the oceanic flora received at the hands of naturalists the attention it merited, although in our own day it has become so favourite a study that few departments of botany can boast of so large a number of distinguished cultivators.

At the present time the superior Fungi are, it must be admitted, very indifferently studied; and consequently their geographical distribution is more imperfectly known than that of the other classes of the vegetable kingdom. The majority of those who make the Fungi a special study are almost exclusively interested in the Mucedines, in the lower forms of the class, and in the parasitic and epiphyllous species. One reason for this predilection for those tribes of Fungi is doubtless to be found in the circumstance that they may be more readily preserved in herbaria, and that in consequence it becomes more easy, by the aid of such collections, to determine species already known. A similar advantage, on the other hand, is unattainable in the case of the higher Fungi; for their fugacious nature, and the difficulty encountered in attempting to preserve their colour and natural form, compel naturalists on every occasion to procure fresh specimens and study them anew, at the sacrifice of much time and labour bestowed in the task of making themselves acquainted with what has been already made out. The same cause renders

it incumbent on the observer to carry on his researches on the living plants where they happen to grow. Such, I believe, are the principal circumstances which deter mycologists of the present day from the study of the higher Fungi; for, so far as regards the determination of specific forms, it may without fear of contradiction be maintained that it is more easy in their case than in that of other Cryptogamia.

The most certain means of obviating the difficulties pointed out is to make a collection of faithfully drawn and coloured figures, which may compensate for the absence of actual specimens; and, in fact, no division of the Cryptogamia is so thoroughly illustrated in books as that of the higher Fungi. It is a point of the greatest interest to science that the original drawings of the figures contained in the works of L'Ecluse and Sterbeeck should be most carefully preserved, and it is most gratifying to learn from M. Kickx that this is done. These drawings are to be seen in the library of Brussels. The published figures are not coloured, and owing to this it often becomes impossible to identify specimens with certainty. The same defect obtains in the plates of the treatises of Micheli, Buxbaum, and Battara, and of other writers prior to Schæffer. The work of the last-named author, entitled '*Icones Fungorum qui in Bavaria et Palatinata circa Ratisbonam nascuntur*' (1762-1774), must be still esteemed of eminent value in all that relates to the higher Fungi. Among other illustrated works of importance are those of Batsch, Bolton, Bulliard, Sowerby, &c.; and a considerable number of useful figures is contained in some works of a more general character, such as the '*Flora Danica*,' the '*Flora Austriaca*' of Jacquin, and in many others of less note.

With respect to synonyms, it must be confessed that the authors just cited, and Persoon himself, have not taken time to study carefully the labours of their predecessors, but have more frequently described as new every form they have met with, except some of the most common and well-known species. The synonymy of this class has therefore been largely added to; and it is only in the '*Systema Mycologicum*' and in the '*Epierisis Systematis Mycologici*' (works by my father) that a complete history of the older literature of the subject is to be met with.

The following observations given by Fries in a foot-note appear to us to deserve a place here, inasmuch as they explain the grand outline of his principles of classification, and furnish a key to the right understanding of the divisions and groups of Fungi hereafter spoken of:—

"The most diverse forms are brought together under the general appellation of Fungi. Adopting the mode of fructification

as the basis for their systematic distribution, we find considerable and essential differences in the manner in which that process is effected present themselves, suggesting a useful division of the Fungi into three subclasses, as follow :—

“1. Fungi properly so called, adopting this appellation in its oldest sense and according to prevailing usage. They are recognized by their *hymenium* (proligerous lamina) bearing free spores, commonly attached in groups of four at the summit of the sporophores. The most highly developed types and the most important Fungi appertain to this subclass, and are further notable in presenting no near affinity either with Lichens or with Algæ.

“2. Semi-Fungi (Mycetes), which also possess a distinct proligerous lamina, but have their spores habitually enclosed, in groups of eight, within enclosed sacs or *asci*. This subclass is constituted of the Discomycetes and Pyrenomycetes, which exhibit a transition towards the Lichens, with the fructification of which they present the closest resemblance.

“3. Moulds (Mucedines), or Fungi destitute of a proligerous lamina, and which are allied by insensible transitions either to the Byssaceæ or, more particularly, to the lower Algæ, from which, in many cases, they are undistinguishable except by habitat and other biological characters.”

Before entering on the account of the distribution of the Fungi, especially of their higher forms, throughout the different regions of the globe, we will point out, in a few words, what are the countries respecting which we have information on this subject, and what is the value of that knowledge. In Europe, Scandinavia and England are the countries most thoroughly and exactly known; and next to them certain portions of France, of Germany, of Italy, of Switzerland, and the environs of St. Petersburg may be mentioned. As to America, many remarkable Fungi have for a long time been known to flourish there. Bosc was the first to furnish some special though imperfect notices of American Fungi; but Schweinitz may be looked upon as having been the true founder of American mycology, by the publication of his work on the Fungi of Carolina and of the United States generally. Several distinguished naturalists occupied in the special study of mycology are to be found in America, among whom Messrs. Curtis, Ravenel, and Lecomte may be named. Some considerable collections have, moreover, been transmitted to Europe by different travellers from the United States and Mexico, and have been described by Berkeley, Montagne, and Fries. Central and Southern America have equally furnished rich collections, which have reached Europe and been described by the same writers. The other portions of the world

are comparatively less known. Asia is little known, except it be the islands of the Indian Archipelago, the Philippine Islands, and the Himalaya Mountains. The most important works on the mycology of these distant regions are those of Junghuhn, relative to the Fungi of Java, and those of Berkeley, which have made us acquainted with the rich collection brought from the Himalayas by Dr. Hooker. With respect to Africa, Algeria has been pretty well explored; Egypt and Guinea have been only partially so; but the Cape of Good Hope and Natal have been examined by several collectors, among whom must be mentioned with especial praise my fellow-countryman, Wahlberg, to whom I am indebted for a rich collection of specimens: nevertheless the mycology of the South Sea Islands (Oceania) is still better known, inasmuch as successful explorations have been carried out by all the scientific expeditions which have visited those parts.

We have deemed it necessary to trace the foregoing sketch of the sources of information to which we owe our acquaintance with the geographical distribution of the Fungi; we will now attempt a brief exposition of this distribution, confining our remarks more particularly to the higher forms (Hymenomycetes and Gasteromycetes), since our knowledge of the inferior or simpler Fungi (Gymnomycetes and Haplomycetes) is as yet too incomplete, and our notions of the characters to which a generic importance should be assigned too vague to allow of the indication of the same general results with regard to them.

I.

With reference to the Gymnomycetes and the Haplomycetes of non-European countries, the United States of North America excepted, little or nothing is known, except it be respecting some parasitic epiphyllous forms. These do not present genera peculiar to the different zones of the globe; yet it must be admitted that the number of their species or forms augments in an equal proportion with that of the plants which inhabit them. In fact, these Fungi are clearly subjected to the same law as prevails with other low organisms, the species of which are spread in a more uniform manner over the globe than those of more highly organized beings. Inasmuch, too, as these inferior organisms are dependent rather upon their matrix and on local conditions than on the influence of climate, we have an explanation why their distinctive differences are of less essential importance. Thus it is a well-known fact that the most common of the mildews, the *Penicillium crustaceum*, is to be met with alike on the Alps of Lapland and in the oasis of Jupiter Ammon in the Libyan desert,—an example which has no parallel in the geographical distribution of the higher plants.

One of the most remarkable circumstances in the history of the lower Fungi is that of their sudden appearance in immense numbers, and their rapid extension, whence, particularly of late years, some disastrous and destructive epidemics, both among animals and plants, have resulted,—as, for example, the ravages produced by the *Oïdium Tuckeri*, the cause or the manifestation of the vine-disease; or the plague-like epidemic of the silk-worm, from the attacks of the *Stachylidium Bassianum*; or the destruction of the common Flies, usually resulting from the parasitic growth of the *Sporendonema Muscæ*. The potato-disease is also accompanied by the growth of several Mucedines; but their presence nevertheless is evidently nothing more than the consequence, and not the efficient cause, of the morbid affection. As another example, it is well to mention the *Lanosa nivalis*, which grows in spring in the melting snow, and is suspected to be the cause, in many instances, of the death of the germs of the sprouting rye.

The semi-Fungi (Discomycetes and Pyrenomycetes) exhibit genera characterized sometimes by a hard and carbonaceous, and at other times by a soft and somewhat waxy texture. The latter consistence predominates among the Discomycetes, and the woody texture among the Pyrenomycetes. The last-named, again, are slow in growth; whereas the Discomycetes increase rapidly, and, moreover, resemble in their mode of development, in many respects, the Hymenomycetes.

The Pyrenomycetes, particularly those that attain the greatest development, have a more extended geographical range than any other of the Fungi. They are to be met with everywhere, except in water [one species, however, the *Sphæria Posidonie*, always vegetates under water], and especially where vegetation of any sort is in process of decay. In fact, they possess a high importance in the general economy of nature, because they accelerate the decomposition of dead and dying organisms. The richer the vegetation of a country is, the more numerous and varied are the forms of Pyrenomycetes to be found there.

The more highly developed Pyrenomycetes evidently have their geographical centre in the torrid and temperate zones; their dimensions and astonishing variety of form increase to the south of the equator, as is instanced in the genera *Xylaria*, *Dothidea*, *Diatrype*, &c.; in the same way *Sphæria* and *Hypoxylon*, between the tropics, vegetate under an infinite variety of forms, for the analogues of which it is vain to seek in the forests of Europe. The superior Discomycetes, on the contrary, such as the Helvellaceæ (*Morchella*, *Gyromitra*, *Helvella*, *Geoglossum*, &c.) and the Bulgariaceæ (*Leotia*, *Bulgaria*), grow by preference in the colder portions of the temperate zone. This circum-

stance is indicated by the fact that their most remarkable species make their appearance ordinarily in early spring, as is observed in the case of *Helvella*, *Morchella*, *Verpa*, *Discina*, and in many of the largest and most beautiful *Peziza*, which, like the *Peziza tuberosa*, *P. acetabulum*, *P. melæna*, *P. coccinea*, *P. majalis*, *P. protracta*, &c., show themselves frequently during the melting of the snow.

Notwithstanding these differences, all the principal groups of semi-Fungi, and their large genera, are common to every country on the globe. Some genera, less rich in species, though remarkable in many points, belong exclusively to particular countries: thus, among the Pyrenomycetes, the genus *Cyttaria* is found to be limited to the region of the Antarctic beech-trees; and among the Discomycetes, the genus *Spadonia* has been observed only in Brazil. Many, however, generally reputed to be peculiar to certain countries, have at a later period, by means of more attentive researches, been discovered elsewhere,—as, for example, the genus *Urnula*, which was at one time considered peculiar to North America, is found to be represented by the *Urnula minor* in Guinea. In the same way another genus of North America has been discovered by M. Lindblad in Sudermania.

Among the Pyrenomycetes there are not a few very remarkable genera peculiar to tropical countries; such are *Thamnomycetes*, *Camillea*, *Kretschmaria*, *Leveillea*, &c., and probably many others yet unobserved amid the rich vegetation of those regions. An attempt to point out what genera of Pyrenomycetes are there absent would be too daring a proceeding in the present imperfect state of our acquaintance with respect to the Micromycetes of those countries; for these productions of the vegetable world are rarely gathered by travellers, to whom it is that we are indebted for the materials for our study. What strikes the attention of the observer is the circumstance that several large genera of Fungi evidently correspond to each other, one in the torrid, another in the temperate zone; for example, in the temperate zone, the *Erysiphæ* are evidently the analogues of the *Meliolæ*, which inhabit the torrid zone.

The Tuberaceæ, properly so called, must be placed with the Mycetes (semi-Fungi), by reason of their spores being enclosed within thecæ. Although at first sight they resemble rather the Gasteromycetes, and, by their mode of evolution, the Hymenogastres, still their fructification is so different that they must be referred to the division before named. There are also intermediate forms between the Tuberaceæ and the other semi-Fungi—as, for instance, certain hypogeous *Pezizæ*, such as the *Peziza sepulta*, which makes its appearance yearly, after the copious rain of autumn, in the sanded avenues of the Botanical

Garden of Upsala. The poverty of Sweden in representatives of the Tuberaceæ is a remarkable peculiarity of the country—one genus only, and in fact only one single, recently discovered species of that genus, viz. the *Tuber niveum* (*Terfezia Leonis*, Tulasne), being found in two places in Ostrogothia; and even there it appears to be rare. On the contrary, in Central and Southern Europe these Fungi are common; and even in the south of England their species are tolerably numerous. The reason for the presence of a greater variety of species of this group of Fungi in England is to be found in the circumstance that the Tuberaceæ are developed chiefly during the winter, and because England, by reason of its insular position, enjoys milder winters and has a greater rainfall, and thereby furnishes more favourable conditions for the vegetation of these Fungi. In Sweden, on the contrary, the severe cold of winter and the frozen soil preclude the growth of Tuberaceæ. These Fungi, in conclusion, have their centre in the warmer regions of the temperate zone; for in hot climates their evolution is often interrupted or destroyed by the excessive heat.

II.

Heat and humidity are the two conditions generally recognized as most concerned in the vegetation of a country. No order of plants is more dependent on these conditions than the Fungi,—a fact peculiarly true in reference to the higher forms, or true Fungi, Hymenomycetes and Gasteromycetes, many of which do not make their appearance unless the weather is peculiarly favourable, or, in other words, after very abundant rains. Plants of this sort, which only show themselves under extraordinary atmospheric conditions, are called “*meteoric*.”

The fact must not be lost sight of in this place, that some species of Fungi which have formerly been common in certain localities may become within our lifetime more and more scarce, and even altogether cease to grow there. The cause of this, doubtless, is the occurrence of some change in the physical constitution of a locality, such as that resulting from the destruction of a forest, or from the drainage by ditches and cuttings of more or less extensive swamps, or from the cultivation of the soil,—all of them circumstances which cause the destruction of the primitive fungaceous vegetation, and the production of a new one. If we compare the fungaceous flora of America with that of European countries, we observe that the former equals in its richness and the variety of its forms that of the Phanerogamous flora; it is probable, however, that, in the lapse of more or fewer years, this richness will decrease in consequence of the extension of cultivation—as is illustrated, indeed, in what has

already taken place in the more thickly peopled districts, as, for example, in the vicinity of New York

There is this difference between the Fungi and other vegetable productions—that the former seem to be especially dependent on the existence of humidity, whilst heat is the more essential condition to the development of plants of a higher organization. Thus it is that the richness of vegetation in general and its whole aspect differ so remarkably, according as the country in question varies in regard to temperature, whereas the amount of atmospheric moisture and rain predominates as the cause which most materially determines the differences in the vegetation of Fungi. Meteoric forms are likewise met with among the higher Fungi, which become developed principally in hot years, and in localities which are, as a rule, under water, but have become dried up by the heat. A parallel to this is to be found among those Phanerogamia which in nature make the nearest approach to Fungi, as, for example, *Orobanche* and *Monotropa*, which flourish in the greatest abundance when the temperature ranges high and repeated rains sodden the soil.

Further, the circumstance that the higher forms of Fungi more especially flourish during the colder weather at the close of autumn, such as, for instance, *Agaricus velutipes*, *A. serotinus*, *A. melleus*, &c., proves that heat is not an indispensable condition to the growth of these plants. Still it cannot be denied that the fungaceous vegetation is usually more luxuriant if there is an abundant fall of rain in August; and it is under such circumstances that the *Amanitæ* and *Boleti* make their appearance in the greatest number. From the fact of North America, where rain falls very copiously, being one of the countries most fruitful in Fungi that is known, the deduction may be fairly drawn, that moisture is a physical condition peculiarly favourable to the development of those plants.

The globe is divisible into several zones, according to the degree of heat, and its more or less unequal distribution throughout the course of the year: but, so far as the geographical distribution of the Fungi is concerned, these divisions have very little practical or useful application; for the differences discoverable between the fungaceous vegetation of particular regions are not so strongly marked as in other cases, and it often happens that countries widely separated possess the closest affinities in reference to their indigenous Fungi. It is enough to admit of the existence of two zones, peculiar in their fungaceous growths—namely, a temperate and a tropical zone; for the frigid zone of geographers produces no peculiar types different from those of the temperate zone; it is merely poorer in species. As to the tropical and subtropical zones, no essential distinction can be

pointed out in the present state of our information respecting their fungous inhabitants. However, these statements are not to be interpreted to signify the existence of any well-defined limits; for either one of the zones described passes insensibly into the other in countries intermediate in position, as is especially illustrated in North America, where the tropical forms of Fungi extend themselves far northward.

The characteristic differences of the two zones are obscure in the case of the lower orders of Fungi, but much more striking in the higher forms. They are particularly evident in the Gasteromycetes, several genera of which are the denizens specially of tropical lands, and among the Hymenomycetes, which in these same regions assume a tough and woody consistence, whereas in the cold and temperate zones of the globe they become more fleshy, and are decomposable with greater rapidity. It has for a long time been the belief that the fungaceous vegetation of the tropics was poor, because it was imagined that the heat would arrest its development; but more attentive observation proves the fallacy of this opinion. It is only in the most arid regions of the earth that a distinct fungaceous flora appears to be wanting. In the primitive forests of tropical countries the presence of Fungi is not connected, as it is in these temperate regions, with a particular season; it is constantly the same throughout the year.

Whilst the species of Fungi in the temperate zone are distributed in a very uniform manner, they appear to follow, on the contrary, in tropical regions, a more special plan of diffusion in the several countries. However, there are Fungi that may be called cosmopolitan, such as *Agaricus* (*Amanita*) *muscarius*, *A.* (*Psalliota*) *campestris*, *A.* (*Naucoria*) *pediades*, *Schizophyllum commune*, *Polyporus versicolor* and *P. igniarius*, *Lycoperdon gemmatum* and *Lycogala epidendron*, &c.

Great differences have been noticed, in reference to their fungaceous vegetation, between Cuba, Java, and the Philippine Islands; yet in all these countries the preponderance of the *Polypori* is a fundamental or characteristic feature. That the fungaceous floras of very distant countries may be very similar is distinctly shown in the instance of North America, which possesses the majority of European species, besides those others peculiar to itself. The island of Juan Fernandez, which has been very carefully explored, presents a fungaceous vegetation differing in only one-third of its forms from that of Europe. The same holds true, it is asserted, with respect to the Fungi of New Zealand and of Australia, although these countries do also possess indigenous genera unknown in Europe.

Since the Fungi are less dependent on heat than on the

moisture of the climate and on the nature of their matrix, the two mycological zones already distinguished are divisible into several regions according to their greater or less amount of humidity, and not according to their latitude or their elevation above the sea; for these are circumstances that seem to exercise little or no influence upon the Fungi. In this fact we get an explanation why the fungaceous floras of Southern and of Northern Europe respectively differ essentially so little that no distinction can be justly instituted between them; indeed, with reference to this point, it would perhaps be easier to separate Eastern from Western Europe.

In any region whatever, it is necessary in the first instance to draw a distinction between its open naked plains and its wooded tracts. In the level open country there is a more rapid evaporation of the moisture by the conjoined action of the sun and wind; whence it happens that such a region is more bare of Fungi than one that is mountainous or covered by woods. On the other hand, plains possess several species peculiar to themselves, as, for example, *Agaricus* (*Naucoria*) *pediades*, certain *Tricholomata*, and, above all, the family Coprini, of which they may be regarded as the special habitat. The species of this family augment in number, in any given country, in proportion to the extent and degree of its cultivation; for instance, they grow more luxuriantly in the province of Scania, in Sweden—a district further distinguished above all others by its cultivation and fertility. In well-wooded countries, moisture is retained a much longer time, and, as a result, the production of Fungi is incomparably greater: and it is here desirable to make a distinction between the Fungi growing in forests of resinous-wooded trees (*Coniferæ*) and those which inhabit woods of other trees; for these two descriptions of forests may be rightly regarded, as to their fungaceous growths, as two different regions. Beneath the shade of *Coniferæ*, Fungi are earlier in their appearance, so much so that it often happens they have attained their complete development when their congeners in forests of non-resinous trees have scarcely commenced their growth. In woods of the latter sort, the fallen leaves, collected in thick layers, act as an obstacle to the soaking of moisture into the earth, and thereby retard the vegetation of Fungi; on the other hand, such woods retain moisture longer. These conditions afford to several large and remarkable species the necessary time for development. I will cite, for example, *Polyporus frondosus*, *P. umbellatus* and *P. giganteus*, *Hydnum erinaceus*, *H. coralloides*, *H. septentrionale*, &c. The beech is characteristic of our own region; but further north this tree gives place to the birch. Coniferous woods are, moreover, divisible into two regions—that of the Pines and that of the Firs.

The latter is richer in species than the former, because, as is well known, fir-trees flourish in more fertile and moister soils. Whether, with respect to the south of Europe, other subdivisions into regions are required, we know not; still less are we able to decide on the like question in reference to the countries beyond Europe.

We will now point out in a few words the great differences which prevail between alpine regions of the temperate zone and those of the tropical zone in relation to the distribution of Fungi. In Lapland, according to Wahlenberg ('*Flora Laponica*') and other travellers, the higher forms of Fungi are excessively scarce. Here and there, and only in the forests, some of the lower Fungi or rare Agarici are scattered. The cause of this circumstance is readily understood when we reflect that the summer is hot and of very brief duration, and that the autumn is exceedingly short, and, moreover, accompanied almost daily with severe frosts. In the districts of Nordlanden and of Finmark, which border on the sea, and enjoy by that position a milder climate, the Fungi are more plentiful, "*ob rorem marinum ibi frequentissimum*," as Wahlenberg remarks. In the marshes and on the borders of the lakes of Lapland several Fungi grow, such as *Mitula paludosa*, *Spathulea flavida*, *Cantharellus lobatus*, &c.; but, from all that we know, the Alpine region of Lapland is the poorest of all in species of Fungi. Wahlenberg remarks that, in the case of the subalpine forests of the Carpathians, the number of Fungi is rather considerable, which shows that in the latitude of this chain of mountains they are more abundant than amid the frosts of Lapland. But if we turn towards the alpine regions of tropical countries, we encounter an entirely opposite state of things; for it is among them that the fungaceous vegetation is most rich in forms and most luxuriant, in situations where the elevation above the sea-level secures a temperate climate. Thus, Junghuhn ('*Præmissa in Floram cryptogamicam Javæ insulæ*'), during his stay in Java, discovered that Fungi grew especially at an altitude of from three to five thousand feet above the sea, and that their abundance decreased above as well as below that zone; moreover the vegetation of the Fungi proceeded unimpeded during the whole year, notwithstanding the variation of the seasons. The same thing has been observed in other tropical countries, as, for instance, in Central America and in the East Indies. In the alpine regions of Upper Asia, Dr. Hooker (see Berkeley, '*Decades of Fungi*,' Dec. xxxii.; xxxiii.) has remarked that Fungi were most abundant at an elevation of seven or eight thousand feet above the sea, and were at the same time very scarce in the plains.

The *stations* of species are determined by the physical conditions presented by different localities. In relation to this subject, a distinction must be made between Fungi which grow from the soil (*Fungi geogenei*) and those which grow on dead plants (*Fungi epiphyti*). The most highly developed and perfect species of each series all grow on the ground, as *Amanita*, *Boletus*, &c. ; they are epigeous, though the mycelium of most of them vegetates beneath the soil upon decayed wood or the worn-out bark of trees. The species lowest in the scale of organization are, on the contrary, epiphytes. Among those Fungi whose existence is most independent of the influence of light, there are several species, and even entire orders, such as the *Tuberi*, which are '*hypogeous*,' or, in other words, which live entirely beneath the surface of the ground. The most evident proof attainable as to how far the development of Hymenomycetes requires the action of light is, that such as have not been exposed to its influence (those, for example, which have lived in the galleries of mines, in caverns, or in hollow trees) assume strangely anomalous forms. The metamorphosis of such individuals remains incomplete, or, in other words, every Fungus preserves its mycelium-nature, its abnormal growth being limited to a monstrous modification of this mycelium.

The '*coprogenous*' Fungi (those growing on manure and those which flourish on decayed wood) occupy an intermediate position between geogenous and epiphytic Fungi. These coprogenous forms acquire their complete proportions in a very brief period, and are decomposed with similar rapidity, in consequence, without doubt, of the great quantity of nitrogen they imbibe in their ordinary matrix. On the contrary, the Fungi which live upon trees grow very slowly, on account of the hardness of the *substratum*; many species of them, which live at the expense of the hard wood or of the bark, are perennial, and annually form new layers overlying those of older date. These perennial species abound in tropical climates, and decrease in number gradually as we approach the poles. It might, *à priori*, be supposed that these Fungi would, on account of their solid texture, suffer less from the effects of cold, and that, for this reason, they would advance further north in their distribution: such, however, is not the case; for it is those Fungi which most speedily attain their full and complete development which are found to exist at the greatest altitudes on the Alps; and this so happens because their development may be frequently accomplished within the space of twenty-four hours.

The influence of the chemical constitution of the soil on the production of Fungi is not at present understood; but it is perfectly well known how materially the richness of the soil in

“humus” contributes to the beauty and abundance of fungaceous vegetation. An essential difference among the various Fungi must, however, be noticed; for whilst certain of them, such as *Cortinarius* and *Hydnum*, avoid all cultivated ground, for the reason that it is too much impregnated with animal matters, others, on the contrary, as *Pratellus*, *Panæolus*, and, above all, the *Coprini*, are never found to flourish elsewhere. Sandy plains are always very poor in Fungi; but the rare species which do grow in such localities are peculiar to them: as instances of this may be cited *Agaricus* (*Inocybe*) *maritimus* and *Peziza arenaria*. No Fungi grow in water; still, in connexion with species of *Sphagnum*, in marshes, several species are met with, the pilei of which alone show themselves above these submerged mosses.

The epiphytous Fungi are not parasites properly so called (as many Fungi belonging to the lowest families or the lowest ranks in the class are); for they never grow except on those parts of plants that are in a state of decay or of decomposition. For though it often happens that Fungi are seen growing on trees still living, yet, if a closer examination be made, it will always be found that they have their nidus in an altered or decayed portion of the wood, even when the superposed bark itself appears to be sound.

Certain Fungi are peculiar to certain trees, and are found on no others—a circumstance which particularly arrests the attention when the Fungi proper to coniferous trees are compared with those that live on trees with large and deciduous leaves. But, further, among the latter forms of Fungi there are species which exclusively belong to certain species of trees. The following are examples of some such:—*Agaricus* (*Pleurotus*) *utnarius* and *A. ostreatus*, together with *Polyporus squamosus*, grow upon most of our deciduous-leaved trees; *Agaricus* (*Armillaria*) *mucidus* finds a fitting habitat only on the beech-tree, *Fistula hepatica* only on the oak, and *Polyporus salignus* and *Trametes suaveolens* only on willows; *Agaricus* (*Omphalea*) *campanella* and *Hydnum auriscalpium* grow on the leaves and cones of pines, *Trametes pini* on the trunk of the same trees; whilst *Polyporus abietinus* and *Trametes odorata* grow only on the fir. The Hymenomycetes which lead a parasitic existence upon other Hymenomycetes—for instance, *Agaricus* (*Mycena*) *pilipes*, *Ag.* (*Collybia*) *tuberosus*, *Boletus parasiticus*, *Nyctalis parasitica*—are all meteoric, and are among the most singular of the Fungi.

It would be superfluous to follow out these general observations on the stations of Fungi in detail, and we will content ourselves by referring the reader to the work of M. Nicolas

Lund, entitled 'Conspectus Hymenomycetum circa Holmiam crescentium.'

In botanical geography, great importance is attached to the differences prevailing among plants in relation to their distribution, according as they are diffused, isolated, or numerous in the localities they inhabit. These differences are, in the case of the Fungi, even more manifest than among the Phanerogamia: there are species of Fungi of which isolated individuals only are to be found; others always met with in groups of larger or smaller numbers; and others, again, which constantly grow in dense clusters or aggregations. Among those species of the second variety named which are collected in social groupings, the aggregation is frequently the result of all the individuals springing from a common mycelium. Sometimes such collections form in extended circles or in long lines, according to the mode of development of the mycelium, which at times expands itself in a centrifugal manner, or circularly, and develops the Fungi at its periphery, and at others elongates itself only in one direction. The *Merulius lacrymans* (the common Fungus of the house) grows in a circular fashion, and attracts moisture from the atmosphere, which it afterwards exudes from its periphery in the form of aqueous drops: by this property it hastens the progress of decay of the wood, which is a necessary condition to its development. In hot countries a no less curious form of mycelium is observable, consisting of a filamentous mucilage, to which particles of earth, small stones, and other fragments of matters it encounters in its expansion become so agglutinated as to constitute a sort of conglomerate, which, on being dried, assumes a hardness equal to that of stone itself. In this manner the *pietra fungaja* of Italy is formed by the mycelium of *Polyporus tuberaster*; in tropical countries, some similar productions are due to the mycelium of certain species of *Lentinus*.

The stations of Gasteromycetes are generally the same as those of Hymenomycetes. The Phallodei and the Hymenogastrei, which are the most important groups of Gasteromycetes, all grow upon the ground—are geogenous. The Nidulariacei and the Lycoperdacei are partly geogenous and in part epiphytes. Among the Trichodermacei are the two singular genera *Asterophora* and *Onygena*, the former of which is parasitic on other Fungi, whilst the most remarkable species of the latter live on animal refuse; thus *Onygena equina* has its special habitat on the hoofs of the horse, and the *O. piligena* on the hair and skin of dead Mammalia.

The other families of Fungi exhibit in regard to habitats (*stations*) many remarkable examples. The species of the subgenus *Hypomyce*, belonging to *Hypocrea*, form a lining to the

hymenium of various Hymenomycetes; but they only show themselves in certain years peculiarly favourable to the production of Fungi, and then they ordinarily occur in great abundance. How and where their spores are preserved in the intervals of these recurrent appearances is a question that cannot be satisfactorily answered. Several species are epizöic, as, for example, some species of *Cordiceps* among the Pyrenomycetes, and sundry *Isariæ* among the Gymnomycetes,—the examples of the genus first named living upon the larvæ of insects, whilst those of the second live upon perfect insects. Only one example of an epizöic Hymenomycetes can be adduced, viz. *Agaricus (Clitocybe) cerussatus*, γ. *nauseosus*, which has been met with in Russia on the carcase of a wolf; this habitat may, however, have been merely accidental.

The Myxogastres exhibit, with reference both to their habitats and to their entire development, a striking contrast with other natural families among the Gasteromycetes. They are frequently destitute of a visible *matrix*; their spores, in the course of development, form a drop of mucilage, which, in certain species, augments with incredible rapidity, and assumes a very great variety of shapes: of the most remarkable types among these are those which protrude vein-like rays, which spread themselves outwards over surrounding bodies, even on living plants, and by their ramifications produce a sort of network. These species often grow with such rapidity that the eye can with difficulty follow their increase, as is illustrated in *Diachea elegans*. The *Spumaria alba*, a common species of Myxogastres, hangs like a frothy mucoid mass to the stems of grasses*; and when fructification, or the actual Fungi make their appearance on this mycelium, they have neither the form, nor the consistence, nor the colour of the primitive mucus, but the whole organism assumes a yellow hue, whilst, too, its spores are black. Similar transformations largely prevail among the Myxogastres: hence it is necessary to follow attentively the different phases of their development, in order to avoid the mistake of constructing several species out of any one of them.

* Dr. W. Nylander, the translator of Fries's memoir into French, appends the following note to these remarks:—"From the not very correct manner in which Fries here speaks of the Myxogastres, and especially of the *Spumaria alba*, it might be suspected that his views respecting these Fungi are not very exact. Some readers might even suppose that an imperfect examination had led him to confound the mucoid mass which conceals the larva of *Cercopis spumaria* with the earliest phase of development of the *Reticularia alba*—a Fungus certainly less common in Sweden than the homopterous insect above named: at least, the preceding remarks of Fries concerning the first stage of *Spumaria* apply with more truth to the singular product from the *Cercopis*."

After these general observations, we will now proceed with a more detailed exposition of the geographical distribution of the principal genera of Hymenomycetes and Gasteromycetes, with respect to which it is often very difficult to decide whether their centre is in the tropical or the temperate zone.

III.

The most important family in the immense class of Fungi is without question that of the Hymenomycetes, which far excel all other Fungi both by the richness of their organization and the beauty of their forms. We have already mentioned the principal distinction which prevails extensively between the Hymenomycetes of the south and those of the north, the fleshy species predominating in the colder and the ligneous in the hot zone. Another circumstance to be noted, on making a comparison of the *Hymenomycetes pileati* of Europe with those of countries out of Europe, is, that while the differences obtaining between the specific types is considerable, there are few or none to be found between the several tribes; and further, the genera are always the same.

The genus *Agaricus* occupies the first rank among the Agaricinæ, and surpasses in the number of its species all the other generic groups known. In the present state of our knowledge, it appears to be well established that the *Agarici* have their geographic centre in the temperate zone, and especially in the colder portion of that zone, as though nature had destined them in those regions for the nourishment of their inhabitants; in fact, they largely serve this purpose in many countries, such as Hungary, Russia, and in general all the Slavonic territories. In Sweden alone, from the domination of vulgar prejudices, are their useful purposes overlooked and ignored. It is a curious circumstance that all the extra-European species of this genus *Agaricus* may be referred to various European subgenera.

In tropical countries it appears that the *Agarici* occupy only a secondary position in relation to other genera of Fungi, such as *Polyporus*, *Lenzites*, &c. North America, on the other hand, is richer in species of *Agaricus* than Europe; for, whilst the majority of typical forms are common to both continents, America further possesses many species peculiar to itself. In the temperate zone, so close is the analogy prevailing between the various countries in respect to the Agaricinæ, that from Sweden to Italy, and as well in England as in North America, the same species are to be found. Of five hundred Agaricinæ met with in St. Petersburg, there are only two or three which have not been discovered in Sweden; and again, of fifty species known in Greenland, there is not one that is not common in Sweden.

The same remarks hold good in reference to the Agaricinæ of Siberia, Kamtschatka, the Ukraine, &c. The countries bordering upon the Mediterranean possess, however, several peculiar types; and Eastern and Western Europe present certain dissimilarities in their Agaric inhabitants. Several species, for example, of *Armillaria* and *Tricholoma* which have been found in Russia have been met with in Sweden only in Upland, that is, in its most eastern province; all the species which belong to the so-called *abieigno-rupestres* and *pineto-montanæ* regions of Sweden are wanting in England; and it is only in Scotland that the species of our northern mountainous and pine-bearing region are met with—a circumstance explicable from the similarity in physical features between Sweden and the northern portions of Great Britain.

The species of *Coprinus* appear to find suitable habitats in every quarter of the globe.

The *Cortinariæ* predominate in the north: they abound in our latitude, especially on wooded hills; but the plains offer also some peculiar species, which germinate during the rainy days of August and September. In less cold countries they are more scarce, or entirely absent. The species of the genus *Hygrophorus* would at first seem to have a similar geographical distribution to those of the last group: but this is really not the case; for the same *Hygrophori* are to be found in nearly every country of Europe, and even the hottest countries (and those under the equator) are not destitute of representatives of this wide-spread genus.

The *Lactarii*, which are so abundant in the forests of Europe and North America, appear to grow more and more scarce towards both the south and the north. The same may be stated in regard to *Russula*.

The genus *Marasmius* is dispersed throughout the globe, and everywhere presents numerous species. In intertropical countries they are still more abundant, and exhibit peculiarities in growth which probably might justify their collection into a distinct group.

The genera *Lentinus* and *Lenzites* are found in every region of the world; their principal centre, however, is in hot countries, where they attain a splendid development. On the contrary, towards the north they rapidly decrease in number.

The *Polypori* constitute a group which, unlike that of the Agarics, especially belongs to hot countries: the *Boleti* constitute the only exception to this rule, since they select the temperate and frigid zones for their special abode, and some of them at times find their way to the higher regions of the Alps. No one can describe the luxuriance of the torrid zone in *Polypori*

and *Trametes*, genera of Hymenomycetes which flourish beneath the shade of the virgin forests, where perpetual moisture and heat promote their vegetation and give rise to an infinite variety of forms. But though the genus *Polyporus*, which rivals *Agaricus* in the number of its species, inhabits in preference warm climates at large, it nevertheless exhibits species peculiar to each country. This arises from the circumstance that the *Polypori* for the most part live upon trees, and are dependent on this or that particular tree for a suitable habitat; and the tropical flora being prolific in trees of all kinds, a multitude of the most varied forms of these Fungi is a necessary consequence. *Hexagona*, *Favolus*, and *Laschia* are common in intertropical countries, but none of them grow in temperate climes.

When the majority of the species of a genus are of a fleshy consistence, it may generally be concluded that that genus belongs to a northern region, even if it should have some representatives in lands which enjoy more sunshine. Thus the *Hydne* are the principal ornaments of our forests, where they attain so luxuriant a growth and beauty that every other country must yield the palm to Sweden in respect to them. In an allied genus, that of *Irpex*, the texture assumes a coriaceous consistence, and we find its species to be more especially inhabitants of warm climates.

Most of the genera of Auricularini are cosmopolitan; and the same is true of some species of *Stereum*, of *Corticium*, &c., which are met with in countries of the most different geographical position. In tropical countries, these genera of Fungi assume the most curious and luxuriant forms. The single and not considerable genus *Cyphella* appears to be pretty uniformly distributed over the globe. The *Clavarini* are equally universal in their diffusion, although more plentiful in the north; however, the genus *Pterula* possesses several exotic forms, though in Europe it has but two representative species. That beautiful genus of Hymenomycetes, *Sparassis*, occupies a similar place next the *Clavarini*, and is peculiarly a production of the temperate zone and of the Coniferous region.

The Fungi which constitute the family of Tremellinei prevail in Europe, Asia, and North America, and exhibit no marked differences among themselves, notwithstanding the distances of the several countries apart. It must, however, be stated that the *Hirneolæ* inhabit only the tropics.

We come now to the Gasteromycetes—an interesting family, which exhibits several ramifications or particular series of developments. The most perfect Gasteromycetes almost exclusively belong to the warmer division of the temperate, and to the tropical zone, where their vegetation is the most luxuriant. Of

late the catalogue of these Fungi has been greatly enriched by the addition of numerous genera and species proper to hot countries, previously unknown. Not uncommonly the exotic floras differ from ours not merely in respect of the species, but also of the genera of Gasteromycetes. It must, besides, be observed that this family is rich in well-defined genera, though very poor in distinct specific forms. Among the genera found in Europe, many are cosmopolitan.

The *Phallodei* present themselves in the torrid zone under the most varied form and colouring, and comprise many genera rich in species. In Europe their number is very restricted. As we advance northward, they decrease rapidly, so that the central districts of Sweden possess only a single species, the *Phallus impudicus*, and even this solitary representative of the family is very scarce. In Scania, the most southern province of Sweden, there is likewise but one genus and one species belonging to it, viz. the *Mutinus caninus*. Among other members of the *Phallodei* may be further mentioned the *Lysurus* of China, the *Aseroë* of Van Diemen's Land, and the *Clathrus*, one species of which, the *C. cancellatus*, has a very wide geographical range; for instance, it is found in the south of Europe, in Germany, and in America; whereas the other species of this genus have a very limited distribution.

The *Tuberacei* are remarkable among the Fungi in being all of them more or less hypogeous. They are natives of warm countries, and are distributed into numerous genera and species. The *Tuberaceæ*, equally with the *Tuberei*, constitute in our latitude a group of Fungi very poor in specific forms. The few species of the *Hymenogastres* belonging to Sweden, with the exception of *Hyperrhiza variegata* and one example of the genus *Octaviania*, are confined to the southern provinces. The greater part of this group, like the *Lycoperdacei*, are met with in the temperate zone. Most examples of the genus *Lycoperdon* are cosmopolitan.

The *Nidulariacei* and the *Trichodermacei* appear to be scattered over the globe in a uniform manner, although their species are not everywhere similar. The same statement applies to the *Myxogastres*, which are common in Lapland, and appear to have their central point of distribution in the countries within the temperate zone. At the same time, they are not wanting in tropical regions, notwithstanding that the intensity of heat, by drying up the mucilage which serves as the medium for the development of their spores, is opposed to their development.